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**Automated Generation of Three-Dimensional Virtual Worlds
for Task Explanation
ONR Grant N00014-91-J-1872**

**Quarterly Report
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Our work addresses the combined application of AI techniques and true 3D interaction and display devices to generate knowledge-based virtual worlds. The goal is to develop virtual environments that present high-quality explanations of physical tasks such as those involved in equipment maintenance and repair or training. In our research, we are exploring issues in the automated design of both self-contained virtual worlds and "augmented reality" (in which generated graphics augments the user's view of the real world).

During the first quarter of our three-year contract, which started in September 1991, we began to build some of the new software and hardware infrastructure needed to support our research. In part, we are extending our IBIS (Intent-Based Illustration System) knowledge-based graphics generation system [Seligmann & Feiner 91]. The current IBIS designs static images and user-controlled animation that describe maintenance and repair tasks. We are developing a new version that can work with a prototype see-through head-mounted display that we designed during the summer of 1991 [Feiner & Shamash 91]. The prototype display uses a Reflection Technology Private Eye, a lightweight display whose optics produce a virtual image that can be focused at a user-controlled distance. A Logitech 3D sensor monitors head position and orientation and a mirror beam splitter merges the display's image with that of the surrounding world.

Our accomplishments this quarter included:

- *design of illustrations as overlays.* IBIS's design rule base was developed to synthesize the entirety of an illustration. In contrast, the work performed during the first quarter of our contract explores the automated design of material that supplements the user's view of the surrounding world. We began the development of a preliminary set of design rules that address this difference. For example, one rule states that if IBIS is told to display an object and it determines that the actual object is already within the user's view of the physical world and not blocked by other objects, nothing needs to be done (since the user can see the actual object). Otherwise, if the object is within the user's view and blocked then a depiction of it can be overlaid on the user's view to allow the user to "see through" the blocking objects. Furthermore, if the object is not within the user's field of view, the user must be instructed to find it: one approach that we have

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taken is the use of a textual callout whose leader line points in the direction of the object.

- *3D sensor support software.* We developed support software for the Logitech 3D sensor, a relatively inexpensive ultrasonic 3D position and orientation sensor announced over the summer. (An earlier version of our head-mounted display used a Polhemus sensor.)
- *Multi-ported display-list server.* We designed and implemented a first version of a multi-ported 3D display list server. The server allows processes associated with multiple 3D motion sensors to monitor the motion of the user's head and of other objects in the physical world and modify the display list accordingly. This makes it possible to synchronize the overlaid graphics with the user's view of the surrounding physical world.
- *Registration of generated material with the surrounding environment.* We developed a first version of a set of calibration procedures for registering 3D overlaid graphics with the physical world.

A paper describing this preliminary testbed was submitted for publication [Feiner, MacIntyre, Seligmann 91]. Another paper [Chin & Feiner 92], submitted in early September to the *1992 Symposium on Interactive 3D Graphics*, was accepted. This describes our work on a fast algorithm for computing object-precision penumbras cast by convex area light sources. (While this latter work may sound unrelated to the research goals of our contract, it makes it possible to determine efficiently which objects obscure others, a vital step in the automated design of effective 3D graphics.)

References

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